Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] What is claimed is:

1.A method for detecting a kick in a borehole, comprising:

acquiring a set of measurements with a sonic tool in the borehole;

determining borehole mud slowness from the set of measurements; and

comparing the mud slowness with a selected criterion,

wherein the determining the mud slowness comprises determining fluid mode slowness as a function of frequency for at least one fluid mode, and determining the mud slowness from the fluid mode slowness.

[c2] 2.The method of claim 1, wherein the determining fluid mode slowness as a function of frequency comprises:

estimating normalized wave numbers for the at least one fluid mode;

unwrapping the normalized wave numbers to compute the fluid mode slowness for the at least one fluid mode at all frequencies; and

generating a histogram of the fluid mode slowness versus frequency for the at least one fluid mode.

[c3] 3.The method of claim 2, wherein the determining the mud slowness is by identifying a maximum fluid mode slowness from the histogram.

[c4] 4.The method of claim 2, further comprising removing zero value wave numbers from the normalized wave numbers.

[c5] 5.The method of claim 1, wherein the determining the mud slowness comprises determining a maximum slowness from an asymptotic approach of the fluid mode slowness as a function of frequency in a high frequency region.

[c6] 6.The method of claim 1, further comprising sending a warning signal uphole if the mud slowness exceeds the selected criterion.

[c7] 7.The method of claim 1, wherein the set of measurements comprise signals in a frequency range of 5 KHz to 500 KHz.

[c8] 8.The method of claim 1, wherein the set of measurements comprise signals in a frequency range of 10 KHz to 100 KHz.

[c9] 9.A system for detecting a kick in a borehole, comprising:

a sonic sensor configured to acquire a set of sonic measurements in the borehole; and

circuitry configured to determine borehole mud slowness from the set of sonic measurements and to compare the determined mud slowness with a selected criterion, wherein the mud slowness is determined from a fluid mode slowness derived from the set of sonic measurements.

[c10] 10.The system of claim 9, wherein the mud slowness is determined from an asymptotic approach of the fluid mode slowness towards a limiting value.

[c11] 11.The system of claim 9, wherein the fluid mode slowness is determined by:

estimating normalized wave numbers for a fluid mode;

unwrapping the normalized wave numbers to compute the fluid mode slowness for the fluid mode at all frequencies; and

generating a histogram of the fluid mode slowness versus frequency for the fluid mode.

[c12] 12.The system of claim 11, wherein the mud slowness is determined by identifying a maximum fluid mode slowness from the histogram.

[c13] 13.The system of claim 11, further comprising removing

zero value wave numbers from the normalized wave numbers.

[c14] 14.The system of claim 9, wherein the sonic sensor is configured to acquire signals in a frequency range of 5 KHz to 500 KHz.

[c15] 15.The system of claim 9, wherein the sonic sensor is configured to acquire signals in a frequency range of 10 KHz to 100 KHz.

[c16] 16.The system of claim 9, further comprising a telemetry link configured to send a warning signal uphole when the mud slowness exceeds the selected criterion.

[c17] 17.A system for detecting a kick in a borehole, comprising:
a sonic sensor configured to acquire a set of sonic measurements in the borehole;
processor means adapted to determine borehole mud slowness from the set of sonic measurements and to compare the determined mud slowness with a selected criterion, wherein the mud slowness is determined from a fluid mode slowness derived from the set of sonic measurements; and
the processor means configured to trigger a warning signal when the mud slowness exceeds the selected cri-

terion.

[c18] 18.The system of claim 17, wherein the mud slowness is determined from an asymptotic approach of the fluid mode slowness towards a limiting value.

[c19] 19.The system of claim 17, wherein the fluid mode slowness is determined by:
estimating normalized wave numbers for a fluid mode;
unwrapping the normalized wave numbers to compute the fluid mode slowness for the fluid mode at all frequencies; and
generating a histogram of the fluid mode slowness versus frequency for the fluid mode.

[c20] The system of claim 19, wherein the mud slowness is determined by identifying a maximum fluid mode slowness from the histogram.